Developing a Microbial Monitor With Polymerase Chain-Reaction Technology

Monserrate C. Roman/ED62
205–544–4071

Future manned spacecraft development for long-duration missions will require water reclamation to avoid frequent resupply of water. Monitoring the water-recovery system for potential system process failures and microbial contamination is critical. This project addresses activities needed to further develop available polymerase chain-reaction technology for microbial water monitoring that could be adapted to the *International Space Station* water system. The monitor will be capable of quantifying the total viable microbial population and detecting and identifying viable pathogenic microorganisms in the processed water on a real-time basis.

Ensuring the microbiological quality of potable and processing waters requires the detection of indicator microorganisms. Because the use of conventional methods for the microbial detection and identification are slow and labor-intensive, these methods are not suitable for applications where information is needed within hours. Therefore, development of a water-quality monitor that uses the polymerase chain-reaction technology will enhance the design of the *International Space Station* water-recovery system.

Monitoring the microbial populations and identifying changes in relative populations would indicate that a steady-state balance is not being maintained and will serve as an early warning that the water-recovery system is not functioning properly. The development of a technology for real-time microbial water monitoring will allow consumption of recycled water shortly after processing, reducing the need for prolonged water storage prior to use and thereby reducing the number and size of storage tanks needed.

The University of Alabama in Birmingham, through a subcontract with ION Electronics, addressed the feasibility of polymerase chain reaction technology to develop a microbial water-quality monitor for use on the *International Space Station*. Polymerase chain-reaction is a genetic-based method in which a deoxyribonucleic acid segment of the target microorganism is detected by enzymatic amplification of a single segment to a million fold. The chain-reaction procedure consists of three steps (cycles): (1) the double-stranded helix is heat-denatured, (2) two primers (short single-stranded oligonucleotides—the nucleotide sequence located at the two ends of the target to be amplified) are annealed at low temperature, and (3) the primers are enzymatically extended by deoxyribonucleic acid polymerase (TaqMan) at an intermediate temperature. An exponential increase of the target acid occurs by repetition of each cycle. The chain-reaction amplification is accomplished by using an instrument called a thermocycler, which repeatedly changes the temperature of the sample. University researchers evaluated scientific literature and designed a set of oligonucleotides that could be used to detect potential pathogens in recycled water.

Monitoring the water-recovery system aboard the space station for potential system process failures and microbial contamination is essential for crew health. By developing existing chain-reaction technology, a water-quality monitor could be adapted for space station use and beyond. The monitor could provide rapid detection of target microorganisms with high sensitivity and meet NASA's needs for low power and simple operation.

In addition to potential space applications, a microbial monitor would have Earth applications as well. Potential uses include hospitals, the food industry, water-processing plants, and chemical/pharmaceutical laboratories. Once fully developed, the microbial monitors could become instrumental tools in laboratories concerned with microbial contaminants.

Polymerase chain-reaction technology is relatively new; however, there is an increased application as a method of diagnosis and microbial identification in environmental, clinical, and industrial samples. Collaborations with other interested government agencies could further develop the technology for different applications and prevent duplication of research efforts.

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